Attachment No. 1

APPENDIX A
STATEMENT OF WORK

"Distributed Wind Turbine Competitiveness Improvement Project
Component Improvements and Overall System Optimization – Round 5"

March 11, 2017

1.0 BACKGROUND

The U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Wind Energy Technologies Office (WETO) defines distributed wind (DW) in terms of technology application based on a wind project's location relative to end-use and power-distribution infrastructure, rather than on technology size or project size; thus, the distributed wind market includes turbines and projects of many sizes. Wind systems are characterized as distributed based on the following criteria:

- Proximity to end-use: wind turbines installed at or near the point of end-use for the purposes of meeting onsite load or supporting the operation of the local (distribution or micro) grid.
- Point of interconnection: wind turbines connected on the customer side of the meter or directly to the local grid[1].

At the smaller end of the DW spectrum, the small wind[2] industry in the United States (U.S.) has historically been a leader in the international market. Progress has been made in improving consumer confidence in the products through the creation of the Small Wind Certification Council (SWCC) that is responsible for certifying small wind turbines to the requirements of the American Wind Energy Association's (AWEA) Small Wind Turbine Performance and Safety Standard[3]. Other organizations certify small wind turbines to this standard. Nine small wind turbines have been certified by the SWCC, and 6 have been certified by Intertek.

The National Renewable Energy Laboratory (NREL) is positioned to support U.S. small and midsize wind turbine manufacturers that demonstrate a strong commitment to improving their ability to compete in the global distributed wind market space. Wind technology expertise available at NREL's National Wind Technology Center (NWTC) has been instrumental in the past in supporting technology improvements.

Through NREL, WETO sponsors a multifaceted wind energy research portfolio to assist the U.S. wind industry develop competitive, high-performance technology for global energy markets. One specific program objective is to increase the number of certified small and midsize wind systems and reduce the levelized cost of energy (LCOE) of turbines used in distributed electricity systems to be competitive with retail electricity rates. "The Distributed Wind Turbine Competitiveness Improvement Project (CIP) Component Improvements and Overall System Optimization – Round 5" is intended to target this program objective and increase the competitiveness of U.S. small and midsize wind turbine manufacturers.

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[1] U.S. Department of Energy, Energy Efficiency & Renewable Energy, Wind Program. 2013. *Distributed Wind*. Available at wind.energy.gov/wind_dist_tech.html (last update May 2, 2013)

[2] The US DOE defines small wind as 100kW or less. Applicable standards for turbine certification will be dependent on the rotor swept area (RSA) of the turbine. IEC 61400-02 applies to turbines $\leq 200 m^2$ RSA. The AWEA Standard size limitation is consistent with IEC 61400-2 limitation. Turbines greater than 200m2 RSA must comply with IEC 61400-1, -12, -23, and any other applicable standards.

[3] http://wwwawea.org/learnabout/smallwind/upload/AWEA_Small_Turbine_Standard_Adopted_Dec09.pdf

2.0 OBJECTIVE

The objective of the CIP is to expand U.S. leadership in the domestic and international wind turbine market sector by assisting U.S. manufacturers[4] in lowering the LCOE of wind turbines through component improvements. The expected outcome is an increase in the number of certified distributed wind turbines available for the U.S. market and reduction of the LCOE of these turbines installed in distributed applications. Although DW is not defined by size, for this solicitation the turbine size will be capped at 1000m^2 RSA.

3.0 SCOPE OF WORK

Under the CIP, the Subcontractor shall be selected to conduct work on Component Improvements and Overall System Optimization. This scope of work emphasizes a disciplined engineering development process, tests to verify component, process, or system designs, and documentation necessary for certification and product commercialization. The Subcontractor shall select a baseline wind turbine that shall be the focus of this project. The Subcontractor shall conduct work that supports designing, building, and or testing improved components.

4.0 TASKS

The Subcontractor shall perform the work, conduct the meetings, and deliver the work products described herein, as minimum requirements. The Subcontractor shall comply with the technical requirements described herein. In addition, the Subcontractor shall complete and submit to NREL the applicable "Figure of Merit – Cost of Energy" (**Attachment 4**).

It is anticipated that the Subcontractor shall pursue low risk, medium to high impact, incremental component improvements, rather than experimental, unproven or high risk innovations that significantly alter the turbine configuration. Proposed efforts should focus on high impact components, such as foundations, towers, alternators, rotor components and controls. The Subcontractor shall select specific component(s) of the baseline wind turbine system (e.g., rotor, alternator/generators, nacelle, control and electrical systems, tower, and structure support, including foundation). The improved component development process, in general, involves the design, fabrication, and testing of component(s) or subsystem that is expected to improve the turbine performance, reliability or cost. This could be accomplished through a number of design changes of components or control software.

The Subcontractor shall show that the expected component improvement results in an improved wind energy system performance and must provide the technical rationale for each proposed improvement, carefully assessing the associated risks and benefits. LCOE shall be the primary figure of merit used to compare and track improvements. The baseline costs, and proposed costs resulting from the proposed improvement, shall be provided in the proposal (see **Attachment 4**). A summary of the actual costs shall then be provided as a task deliverable. Therefore, improvements should focus on lowered capital costs, increased performance, improved reliability, and reduced replacement, operation and maintenance costs. The objective within this effort is to show the advantages of a new/re-designed component(s) in support of enhanced capabilities, performance, reliability, and/or reduction in overall costs. Elements of improvements and the need for a rigorous study for the development and manufacture of the component(s) must be identified.

[4] Attachment 3, Eligibility Verification, must be completed and submitted as part of the proposal.

Task 4.1: Communications:

The Subcontractor shall provide information to and engage in scheduled communications with the NREL Technical Monitor throughout the subcontract period of performance to include:

1) A summary of the subcontracted effort, void of business sensitive information, with the following information:
    a. Company name
    b. Company contact/Principal Investigator
    c. Project Title
    d. Approximate Start date/duration
    e. Estimated Project Budget
    f. Statement of Problem
    g. Proposed Solution
    h. Project Deliverables and Milestones
    i. Work to be performed
    j. Anticipated Benefits
    k. Collaborating Entities
2) Information on the work effort suitable for inclusion in NREL and DOE news articles, to include high-resolution photos relevant to the effort for inclusion in NREL's photo database and for public dissemination;'
3) Participation in monthly conference calls with the NREL team; and,
4) Hosting site visits for DOE and NREL to discuss the subcontract work effort.

Task 4.2: Status-quo Analysis, Opportunity Identification, New Specifications:

The Subcontractor shall provide a brief analysis of the opportunity the work effort under this topic will address, starting from the current situation in terms of product configuration and performance, as well as engineering data accumulated to date. This includes drawings, reports, testing data, analysis data and spreadsheets, photographs, etc., that can help identify the requirements of the component(s) of interest. The Subcontractor shall also provide a letter report listing the specifications and requirements of the improved component(s).

The letter report shall also include a discussion of the advantages of the component(s) improvements in terms of manufacturing, reliability, safety, performance and cost together with expected results (e.g., comparisons of load or stress, fatigue life, installation costs, manufacturing costs, etc.).

Task 4.3: Detailed Product Development Plan:

Based on the Product Development Plan, the Subcontractor shall identify all the necessary steps for the engineering of the improved component(s), from conceptual to detailed design, including the methods and tools that are planned for the work. The Subcontractor shall identify the standards being followed and outline the procedures for qualifying the design to meet applicable certification standards. The outline of procedures shall specifically address the approach for the derivation of loads and demonstrate that the turbine design is qualified to use that loads derivation approach.

All of the above items shall be summarized in a Detailed Product Development Plan document and submitted to NREL for review. A Product Development Plan shall include, but not limited to, the following items:

- Product requirements
- Engineering effort
- Prototype development
- Testing effort
- Tooling development
- Manufacturing plan
- Certification plan

Task 4.4: Implementation and Analysis:

The Subcontractor shall execute and complete the component improvement effort as described in the 4.3 plan. The subcontractor shall submit a structural analysis report of the component(s) under investigation, including any test reports, detailed drawings, solid models, and results of models and finite element analyses. If a software or electro-technical component is the focus of the analysis and design, then a detailed analysis report shall be submitted in lieu of the structural analysis (e.g., control system design) report.

If applicable, fatigue damage estimates and associated expected lifetimes of the components shall be reported comparing the new and old configuration data. The standards and codes used in the analyses shall be stated in the report, with particular emphasis on the methodology and assumed load and material safety factors.

Task 4.5: Revised Levelized Cost of Energy:

At the completion of the component improvement work effort, the Subcontractor shall develop a revised LCOE, comparing the baseline, proposed and actual cost elements. The Subcontractor shall summarize the final system costs and describe, in detail, how and why it is consistent or different from the estimates included in the original proposal.

5.0 REVIEW MEETINGS AND TRAVEL REQUIREMENTS

The Subcontractor may, but is not required to, travel to NREL one or more times to discuss the review of tasks or other technical support from NREL. Conference calls and or in-person meetings may be conducted over the course of the subcontract period of performance, and shall be scheduled by either the Subcontractor or the Technical Monitor on an as-needed basis and as mutually agreed to.

6.0 DELIVERABLES

The Subcontractor shall provide the following deliverables:

6.1. The Subcontractor shall submit a summary of the subcontracted effort, void of business sensitive information, as described in Task 4.1. **Due: 1 month from date of subcontract execution.**

6.2. The Subcontractor shall provide a Letter Report providing analysis of opportunity, including supporting documentation as defined in Task 4.2. **Due: 1.5 months from date of subcontract execution**.

6.3. The Subcontractor shall provide a Product Development Plan as defined in Task 4.3. **Due: 2.5 months from date of subcontract execution.**

6.4. The Subcontractor shall provide a Structural Analysis Report, or Analysis Final Report, as applicable to Task 4.4. **Due: 19 months from date of subcontract execution**.

6.5. The Subcontractor shall provide a revised Cost of Energy as defined in Task 4.5. **Due: 20 months from date of subcontract execution**.

6.6. Quarterly Reports: The Subcontractor shall provide quarterly reports to include a description of work performed by the Subcontractor. The report shall describe the status, explain variances and problems, report on accomplishments, and planned activities for the next quarter. **Due: Quarterly from date of subcontract execution**.

DELIVERY OF COMPUTER SOFTWARE CODE (AS APPLICABLE)

All object, source, or other code (including all applicable data sets) developed under this subcontract effort shall be provided to the technical monitor as a condition of final payment, in accordance with the subcontract. It is expected that all delivered source code shall be original and the subcontractor shall provide a written certification to the subcontract associate that all source, or other code developed and delivered under this subcontract does not contain any open source code - as a condition of final payment in accordance with the subcontract. The subcontractor's (including all lower tier subcontractors, as applicable) certification shall specify that "All source, or other software code developed and/or delivered under this Subcontract No._____ is original and does not contain any 3rd party or other open source software."

7.0 ELECTRONIC REPORTING REQUIREMENTS FOR SUBCONTRACT REPORT DELIVERABLES

It is NREL's intention to publish subcontract report deliverables containing publicly available information (e.g. non-confidential, non-protected, non-proprietary information) for distribution on the internet.

The subcontractor shall provide the final approved version of report deliverables in accordance with the electronic reporting requirements described below.

The technical monitor may specifically direct the subcontractor to provide reports in one or more of the file format standards provided below.

a. The subcontractor shall submit all report deliverables (including status, annual, or final reports) as electronic files in Adobe .pdf format, preferably with all graphics and images embedded within the document.

b. All final approved version submissions shall be delivered to NREL via e-mail to the 1) NREL Technical Monitor, 2) the NREL Subcontract Administrator or Associate (as specified in the Deliverable Addresses below).

c. If it is not possible to include all of the graphics and images (figures, illustrations, and photographs) in the same file as the text, NREL will accept the text in Adobe .pdf formats and the graphics and images as separate electronic graphic or image files*. The accepted standard for page layout and graphics is the Adobe Creative Suite of programs.

   *The acceptable graphic or image file formats are: .eps, .tif, .gif, .jpg, .wmf, .emf, .pct, .png, .bmp, .psd, .ai, .fh, .qif, .fpx, cdr. The preferred resolution for graphics or images is 300 dpi. Include all fonts used in creating the file.

d. For animation, video, or multi-media elements, CD-ROM, DVR and thumb drive are acceptable technical deliverable media.

e. For all calculations in support of subcontract reports that are conducted in ASPEN+, an electronic copy of INPUT, REPORT and BACKUP (if Model Manager is used) must be submitted with all reports. Additionally, if costing or sizing calculations are conducted in a spreadsheet [no process calculations (heat and material balances) in spreadsheet format are permitted], a copy of the fully documented MS Excel file shall be supplied.

f. A fully executed model release shall be supplied to NREL with all photographs and images, regardless of whether such photographs or images are delivered to NREL electronically or in hard copy. Such model release shall certify that the Alliance for Sustainable Energy, LLC, Management and Operating Contractor for the National Renewable Energy Laboratory for the U.S. Department of Energy is granted a non-exclusive, paid-up, irrevocable, worldwide license to publish such photographs in any medium or reproduce such photographs or allow others to do so for United States Government purposes. Model releases are required in all situations in which a reasonable person would respond in the affirmative to the question – could someone, other than the model himself/herself, recognize the person in this photograph or image? All model releases shall be provided to the subcontract associate as a condition of

final payment, in accordance with the subcontract. To obtain a Subcontractor Model Release form, please contact images@nrel.gov.

8.0 ACKNOWLEDGEMENTS IN SUBCONTRACTOR PUBLICATIONS

In any scientific or technical report or article, conference paper, journal article, etc. based on or containing data first produced in the performance of this subcontract and published in academic, technical or professional journals, symposia proceedings or similar works, the subcontractor shall use this acknowledgement stating, "This [article, conference paper, journal article, etc.] was developed based upon funding from the Alliance for Sustainable Energy, LLC, Managing and Operating Contractor for the National Renewable Energy Laboratory for the U.S. Department of Energy."

9.0 COPYRIGHT PERMISSION/AUTHORIZATIONS

The subcontractor is responsible for obtaining copyright permissions and/or authorizations for all information and/or data, as applicable that is incorporated into all final technical reports. Electronic copies of these copyright permissions and/or authorizations shall be provided to the subcontract associate at the email address provided below. The subcontractor shall also provide a written certification to the subcontract associate as to such permissions and/or authorizations as a condition of final payment. The subcontractor's (including all lower tier subcontractors, as applicable) certification shall specify that "I have obtained all necessary and legally required copyright permissions and/or authorizations for any and all information, data, graphs, images, etc., as applicable, that is incorporated into the final Technical Report titled _____, delivered under this Subcontract No._____. Copies of these permissions and/or authorizations are attached."

Deliverable Addresses:

The subcontractor shall clearly label all deliverables to include:

- The subcontractor's name
- NREL's subcontract number
- NREL Technical Monitor's name
- Deliverable date, and
- Deliverable description.

Deliverables shall be sent via email to each of the following addresses:

1) **, Technical Monitor
National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
e-mail: **
    - One (1) master electronic version, including graphics

2) **, Subcontract Associate
National Renewable Energy Laboratory
15013 Denver West Parkway
Procurement Office
Golden, CO 80401
e-mail: **
    - One (1) master electronic version, including graphics